

Appl. No. 10/712,818
Amdt. dated August 13, 2007
Reply to Office Action of May 17, 2007

IN THE CLAIMS

A presentation of all of the pending claims with their current status indicated follows.

1. (currently amended) An apparatus for measuring at least one parameter of a process flow flowing within a pipe, the apparatus comprising:

at least two strain sensors ~~clamped onto the outer surface disposable about an outer circumference~~ of the pipe at different axial locations along the pipe, each of the strain sensors providing a respective strain signal indicative of a pressure disturbance within the pipe at a corresponding axial position, each of the strain sensors comprising:

a strap, and

a piezoelectric film material having a pair of conductors disposed on opposing surfaces thereof whereby the piezoelectric film material is attached to the strap which transfers the strain of the pipe to the piezoelectric film material; and

a signal processor, responsive to said strain signals, which provides a signal indicative of at least one parameter of the process flow flowing within the pipe.

2. (original) The apparatus of claim 1, wherein the process flow is one of a single phase fluid and a multi-phase mixture.

3. (previously presented) The apparatus of claim 1, wherein the piezoelectric film material is attached to the outer surface of the strap.

4. (original) The apparatus of claim 1, wherein the strap is a metallic material.

5. (previously presented) The apparatus of claim 1, wherein at least one of the strain sensors include an attachment device for securing the ends of the strap of the strain sensor to clamp the strain sensor onto the pipe.

6. (previously presented) The apparatus of claim 1, wherein the ends of at least one of the strain sensors are removably attached together to enable the removable and reattachment to a pipe.

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7. (previously presented) The apparatus of claim 1, wherein the ends of at least one of the strain sensors are permanently attached together.
8. (previously presented) The apparatus of claim 1, wherein the piezoelectric film material includes at least one of polyvinylchlorine fluoride (PDVF), polymer film and flexible PZT.
9. (Canceled)
10. (previously presented) The apparatus of claim 1, wherein each of the pair of conductors-is a coating of silver ink.
11. (previously presented) The apparatus of claim 1, wherein the piezoelectric film material extends around a substantial portion of the circumference of the pipe.
12. (previously presented) The apparatus of claim 1, wherein the piezoelectric film material has a thickness greater than 8 mm.
13. (previously presented) The apparatus of claim 1, wherein the piezoelectric film material has a thickness between 8 mm and 120 mm.
14. (previously presented) The apparatus of claim 1, further includes an electrical insulator between the piezoelectric film material and the strap.
15. (previously presented) The apparatus of claim 1, wherein the strain signals are indication of acoustic pressures propagating within the pipe.
16. (original) The apparatus of claim 1, wherein the parameter of the fluid is one of steam quality or "wetness", vapor/mass ratio, liquid/solid ratio, volumetric flow rate, mass flow rate, size of suspended particles, density, gas volume fraction, and enthalpy of the flow.

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17. (original) The apparatus of claim 1, wherein the signal processor determines the slope of an acoustic ridge in the k-w plane to determine a parameter of the process flow flowing in the pipe.
18. (previously presented) The apparatus of claim 1, wherein the strain signals are indication of vortical disturbances within the fluid flow.
19. (original) The apparatus of claim 18, wherein the parameter of the fluid is one of velocity of the process flow and the volumetric flow of the process fluid.
20. (original) The apparatus of claim 1, wherein the signal processor determines the slope of a convective ridge in the k-w plane to determine the velocity of the fluid flowing in the pipe.
21. (original) The apparatus of claim 1, wherein the signal processor determines the volumetric flow rate of the fluid flowing in the pipe in response to the velocity of the fluid.
22. (previously presented) The apparatus of claim 1, wherein the signal processor generates a flow velocity signal indicative of the velocity of the fluid flowing within the pipe by cross-correlating the strain signals.
23. (original) The apparatus of claim 1 wherein each sensor measures an acoustic pressure and provides a signal indicative of an acoustic noise within the pipe.
24. (previously presented) The apparatus of claim 1 further comprising at least three of said strain sensors.
25. (original) The apparatus of claim 1, wherein the strain sensors include pressure sensors.

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26. (currently amended) A strain sensor ~~for clamping onto the outer surface of a pipe to provide a respective strain signal indicative of a pressure disturbance within the pipe; said strain sensor comprising:~~

a strap disposable about an outer circumference of a pipe, and
a piezoelectric film material having a pair of conductors disposed on opposing surfaces thereof wherein the piezoelectric film material is attached to the strap which transfers the strain of the pipe to the piezoelectric film material to thereby provide a strain measurement indicative of a pressure disturbance within the pipe.

27. (previously presented) The sensor of claim 26, wherein the piezoelectric film material is attached to the outer surface of the strap.

28. (previously presented) The sensor of claim 26, wherein the strap is a metallic material.

29. (previously presented) The sensor of claim 26, wherein the strain sensor includes an attachment device for securing the ends of the strap of the strain sensor to clamp the strain sensor onto a pipe.

30. (previously presented) The sensor of claim 26, wherein the ends of the strain sensor are removably attached together to enable the removable and reattachment to a pipe.

31. (previously presented) The sensor of claim 26, wherein the ends of the strain sensor are permanently attached together.

32. (previously presented) The sensor of claim 26, wherein the piezoelectric film material includes at least one of polyvinylchlorine fluoride (PDVF), polymer film and flexible PZT.

33. (previously presented) The sensor of claim 26, wherein each of the conductors is a coating of silver ink.

34. (previously presented) The sensor of claim 26, wherein the piezoelectric film material extends around a substantial portion of the circumference of a pipe.

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35. (previously presented) The sensor of claim 26, wherein the piezoelectric film material has a thickness greater than 8 mm.

36. (previously presented) The sensor of claim 26, wherein the piezoelectric film material has a thickness between 8 mm and 120 mm.

37. (previously presented) The sensor of claim 26, further includes an electrical insulator between the piezoelectric film material and the strap.

38. (previously presented) The sensor of claim 26, wherein the piezoelectric film material is attached to the inner surface of the strap.

39. (previously presented) The apparatus of claim 1, wherein the piezoelectric film material is attached to the inner surface of the strap.